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To: **David Fisher**
NZ Herald
NEW ZEALAND

Subject: Answer to New Zealand media query

Dear David Fisher,

Thank you for your recent email and inquiry about the DORIS system.

I write to you in my capacity as the Chair of the International DORIS Service (IDS), a service of the International Association of Geodesy (IAG). DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) is one of the four techniques of Space Geodesy (along with Satellite Laser Ranging, Very Long Baseline Interferometry, and Global Navigation Satellite Systems) that contribute to the determination of the International Terrestrial Reference Frame (ITRF).

The ITRF provides the foundation for all positioning and the framework to situate and geolocate Earth observations in space and time. Geodesy is a discipline of Earth science that measures the shape, rotation, and gravity field of the Earth and how they change with time. Besides contributing to the ITRF, DORIS is used to calculate the orbits of Low Earth Orbiting Satellites where the precise orbits are computed with a radial orbit accuracy of about 1 cm Root Mean Square (RMS). The primary customers are ocean radar altimetry satellites that measure the height of the Earth's oceans. The DORIS/DIODE navigation system on board these DORIS-equipped satellites provides real-time orbits that have been shown to have a radial orbit accuracy of about 3.5 cm RMS. These real-time orbits are released on data streams provided by the mission operation centers of these different altimeter satellites. Near real-time altimeter measurements of ocean height and other products are used by a variety of real-time forecast and data analysis services. For example, one of the applications is to improve forecasts of cyclone intensity.

I emphasize the contribution of the DORIS system, in combination with Satellite Laser Ranging (SLR), of calculating precise orbits for the TOPEX/Poseidon, Jason-1, Jason-2, and Jason-3 missions that have enabled the precise measurement of the global rate of change in mean sea level and its acceleration using ocean radar altimetry data over the past 26 years (*c.f.* Nerem, R.S., et al., *Proc. Natl. Acad. Sci.*, 2018, <https://dx.doi.org/10.1073/pnas.1717312115>). The ocean radar altimetry data from these satellite missions, together with the precise satellite orbits (computed with SLR and DORIS tracking data), and the application of appropriate geophysical and instrumental corrections, are available from both NASA and the French Space Agency (the CNES), including at the following URLs:

https://podaac.jpl.nasa.gov/Integrated_Multi-Mission_Ocean_AltimeterData
<https://www.aviso.altimetry.fr/en/data/products.html>

The DORIS system consists of a satellite constellation, a ground data system, and a global network of sixty beacons that are spatially well distributed over the Earth's surface. The beacons emit signals on two frequencies, at 2.036.25 MHz, and 401.25 MHz. The dual frequency transmissions are received by the DORIS satellites, providing the raw Doppler measurements used for satellite positioning, while correcting for refraction through the Earth's ionosphere. A summary of the current status of the DORIS system is provided in a poster presented at the Fall meeting of the American Geophysical Union (AGU), in Washington DC, December 2018, and is available at the following URL:

https://ids-doris.org/documents/report/meetings/AGU2018_IDS_CurrentStatusAndPlannedEvolution.pdf

Of course, as you are aware, the DORIS network consists of a beacon at Owenga, on Chatham Island in New Zealand. The current network of stations is shown on the website of the International DORIS Service (IDS), <https://ids-doris.org/doris-system/tracking-network/site-logs.html>. The site log, providing details of the instrumentation at the site, is available from this URL. The DORIS station on Chatham Island provides vital tracking coverage for DORIS satellites in the South Pacific, as can be seen on the satellite coverage maps for satellites at altitudes of 1336 km and about 800 km respectively:

Jason-1, <https://ids-doris.org/images/doris/Network57Jason-06-12-08.jpg>

Envisat, <https://ids-doris.org/images/doris/Network56ENVISAT-07-03-07.jpg>

The Institut Géographique National (IGN) in France provided me with a history of the DORIS station in New Zealand, and I summarize that information here. A station operated at Waitangi on Chatham Island, but was removed in May 1990, following a request of the government of New Zealand. In November 1996, the IGN re-initiated contacts with the New Zealand Institute of Geological and Nuclear Sciences (GNS, today) about the possibility of re-establishing a DORIS station in New Zealand. IGNS made an official request to the New Zealand Ministry of Foreign Affairs who replied in July 1997, that they "would welcome and support an installation by the French", and this was confirmed in an official letter in September 1997. In August of 1997, requests were made to the Chatham Island Council and to the New Zealand Met Service about hosting a DORIS station on Chatham Island. The approval of the Chatham Islands Council followed in December 1998 and an agreement was signed between IGN and the NZ MetService in February 1999. A necessary frequency license to operate the DORIS station was provided by the appropriate New Zealand government agency in November 1998 (*DORIS stations in every country must obtain radiofrequency clearance through the local governmental authorities*). The DORIS station "CHAB" commenced operations on February 28, 1999 and operated through November 19, 2014. Since the NZ MetService had advised in 2012 that operations would cease at the Waitangi site, a new station was established at Owenga, also on Chatham Island. The DORIS station at Owenga (OWEC), was established on November 20, 2014 through a partnership with Land Information New Zealand (LINZ). The DORIS station is located close to (co-located in geodetic language) with the "OWMG" station of the International Global Navigation Satellite Systems Service (IGS). These geodetic colocations are a vital part of the determination of the International Terrestrial Reference Frame (ITRF), since it is only at these "colocation sites" that a precise tie vector can be measured between the reference points of the geodetic networks with the desired level of precision (a few mm).

We are grateful to NZ Met Service, Land Information New Zealand, GNS Science, and all the host agencies and local organizations around the world for their support of the DORIS system.

Thank you for your interest in the DORIS system. I apologize for the length of this letter in response to your inquiry, but I wanted to be sure that we provided a complete operational and scientific context for the emplacement of a DORIS beacon in New Zealand. Please do not hesitate to contact us if you have any further questions.

Sincerely yours,



(Dr.) Frank G. Lemoine
Chair, International DORIS Service.

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